REMARKS

Applicants acknowledge the allowance of Claims 20-26 as set forth in paragraph 5 of the Office Action, as well as the indication of the allowability of the subject matter of Claims 17-19, as set forth in paragraph 6 of the Office Action. In particular, the latter claims would be allowable if rewritten in independent form. However, as discussed in greater detail hereinafter, Applicants respectfully submit that Claims 17-19 are allowable in their present dependent form.

In response to the objection to the Abstract of the Disclosure as set forth in paragraph 1 of the Office Action, the Abstract has been revised and attached hereto on a separate page, as required.

The disclosure has been objected to on the grounds that there are no headings. Applicants respectfully traverse this ground of objection, because the substitute specification submitted with the original application papers on April 9, 2001 does in fact contain headings. In particular, the heading "BACKGROUND AND SUMMARY OF THE INVENTION" appears on page 1 prior to paragraph [0001], while the heading "BRIEF DESCRIPTION OF THE DRAWINGS" appears at the top of page 11, preceding paragraph [0019] and the heading "DETAILED DESCRIPTION OF THE DRAWINGS" is on page 12 between paragraphs [0026] and [0027]. Applicants respectfully submit that the format of the application, including these headings comply with all applicable

statutory and regulatory requirements. While the "guidelines" referred to at page 2 of the Office Action constitute a suggested layout of the specification, they are not mandatory and do not require any further headings. Accordingly, reconsideration and withdrawal of this ground of objection are respectfully requested.

Claims 14-16 have been rejected under 35 USC §103(a) as unpatentable over Shetty et al (U.S. Patent No. 5,189,490) in view of Hess et al (U.S. Patent No. 3,877,814). However, for the reasons set forth below, Applicants respectfully submit that Claims 14-16 distinguish over the cited references, whether considered separately or in combination.

The present invention is directed to a method and apparatus for detecting and measuring periodic wave patterns on a microscopic scale in finished or polished surfaces. For this purpose, the surface which is to be tested is illuminated using a primary beam of monochromatic coherent light, which is directed onto the surface at approximately right angles to an expected periodic wave pattern, and at an angle of incidence that approximately grazes the workpiece surface. Such illumination results in the generation of a diffraction image of the wave surface structure in the secondary light beam which is propagated from the surface that is to be evaluated. By analyzing both the intensity and spacial distribution of the diffraction image contained in the secondary light beam, both the period and depth of the wave troughs in the surface can be determined.

More particularly, the occurrence of two intensity maxima indicates the presence of a periodic wave pattern, whose period is evaluated through inverse proportionality from the spacing of neighboring intensity maxima. The depth of the wave troughs, on the other hand, is determined from the intensity of neighboring intensity maxima, and from the period, determined as noted previously. For this purpose, the secondary beam path is subjected to an autocorrelation analysis, and both the period and the depth of the wave pattern are calculated from the autocorrelation function.

The primary Shetty et al reference, cited in the Office Action, discloses a method and apparatus for surface roughness measurement using the phenomenon of light scattering through laser diffraction. A primary light beam is reflected by the surface to be analyzed, and the reflected secondary beam is scattered in a way that is characteristic of the roughness of the structure of the surface. To this extent, the Shetty et al reference is generally similar to the present invention.

Shetty et al, however, does not show a method and apparatus for measuring a waviness/wave pattern in a finished surface (a phenomenon which extends in the direction of the surface) as does the present invention. Rather, Shetty et al discloses a method and apparatus for measuring the surface roughness (a physical quantity which extends in the direction vertical to the surface). Moreover, Shetty et al also does not elaborate on the problem of two

overlaying structural elements of different shape but similar size – a phenomenon which generally occurs in surfaces after grinding. The present invention focuses on the task of evaluating only one of these structural elements (surface waviness), whereas the other structural element expresses itself as speckle noise which considerably inhibits this evaluation.

Both the manner of illumination, and the manner of processing of the secondary light beam in Shetty et al differ fundamentally from those of the present invention. The technique employed by Shetty et al is described generally in the specification at Column 3, line 63 through Column 4, line 16. As noted there, a diffraction pattern is produced in the light reflected from the surface which is to be evaluated. The image of the reflected diffraction pattern is displayed on a display screen, and the intensity data are converted into digital signals. The actual determination of surface roughness is made by comparing the intensity of the captured image with data on intensity from calibrated standard images. For this purpose, it is necessary first to calibrate the system by scanning and obtaining data from standard samples, whose roughness is known. (See, for example, Column 6, lines 46-60; Column 7, lines 16-23; and Column 8, lines 38-42.) Such a calibration is necessary for every new surface type that is to be measured.

Based on the foregoing brief description, it is apparent that there are a number of significant differences between the present invention and the Shetty et al method and apparatus. In particular, the method according to the present

invention requires no calibration such as is required in Shetty et al before a new set of measurements. Moreover, in Shetty et al, there is no discussion or disclosure which suggests that the primary light beam be directed onto the surface at an angle of incidence which approximately grazes the workpiece surface, or in a direction which is substantially at right angles to expected periodic wave patterns. The latter is, of course, not a consideration when surface roughness (as opposed to waviness) is being measured. Indeed, given the methodology described previously, in which the surface roughness is determined simply by a comparison of the reflected light intensity with standardized reference data, there would appear to be no particular criticality to the orientation of the primary light being relative to the surface which is being evaluated or relative to the expected periodic wave pattern. Furthermore, the specification at Column 7, lines 56-59 suggests that the angle of incidence is unimportant, or at least there is no suggestion that any particular angle or range of angles is required. In particular, Shetty et al does not specify an angle of incidence, or whether the light beam is chosen perpendicular or parallel to the lay of the surface.

Even more importantly, however, Claim 14 further recites a step of evaluating the intensity and spacial distribution of neighboring intensity maxima in the diffraction image for the purpose of detecting small periodic wave patterns. This technique, which requires the illumination limitations also recited in Claim 14, is neither taught nor suggested by Shetty et al, in which the surface roughness is evaluated by comparison of the reflected light signals with

standard reference data, as noted previously. In this regard, Applicants note that the Office Action states at the bottom of page 3 that the processing of a diffraction image in a computer necessarily includes measurements with respect to the occurrence of intensity maxima. Applicants respectfully submit however, that such is not the case in Shetty et al. That is, the technique disclosed in Shetty et al, and described in detail above, is unrelated to the occurrence or spacial distribution of intensity maxima. Insofar as Applicants have been able to determine, the disclosure contains no discussion of locating intensity maxima and attributes no significance to the geometric or spacial distribution or relationships thereof. Indeed, there is no discussion of the proposition that two or more intensity maxima may occur, or of the significance thereof.

The Hess et al reference, on the other hand, is directed to a method and apparatus for detecting convex and concave portions in the surface of a glass ribbon, which convex or concave portions have a radius of curvature on the order of magnitude of 80 to 160 meters, as noted at Column 4, lines 8-9. In order to detect such surface irregularities, a collimated light beam is directed toward the top surface of the glass ribbon at a preselected angle of incidence, and the reflected light is measured. Because concave and convex portions in the top surface of the glass increase and decrease the intensity of the reflected beams, respectively, it is possible to determine the existence of large irregularities by observing the intensity of the reflected light in this manner. (See, Column 2, lines 44-63.)

The Hess et al reference fails to teach or suggest those features of the present invention as defined in Claim 14, which are missing in the Shetty et al reference. That is, there is no disclosure of directing the instant primary light beam onto the surface approximately at right angles to an expected periodic wave pattern, and in addition no particular criticality is assigned to the angle of an incidence, other than the fact it must be sufficiently shallow to avoid substantial reflection from the bottom surface of the glass. (See Column 2, lines 59-63.) Even more significantly, however, Hess et al merely monitors the intensity of the reflected light to detect variations. It contains nothing which teaches or suggests that, with the particular limitations on the orientation of the illuminating primary light being recited in Claim 14, the intensity and spacial distribution of neighboring intensity maxima in a diffraction pattern can be used to evaluate the surface roughness, in the manner disclosed and claimed in the present application. Accordingly, the combination of Hess et al and Shetty et al fails to yield the claimed invention.

In light of the foregoing remarks, this application should be in condition for allowance, and early passage of this case to issue is respectfully requested. If there are any questions regarding this amendment or the application in general, a telephone call to the undersigned would be appreciated since this should expedite the prosecution of the application for all concerned.

If necessary to effect a timely response, this paper should be considered as a petition for an Extension of Time sufficient to effect a timely response, and

please charge any deficiency in fees or credit any overpayments to Deposit Account No. 05-1323 (Docket #225/49845).

Respectfully submitted,

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ABSTRACT OF THE DISCLOSURE

In a method and apparatus for detecting small periodic wave patterns in technical surfaces, monochromatic coherent primary light is directed onto a workpiece surface approximately at right angles to the expected periodic wave patterns, and at an angle of incidence that grazes the workpiece surface, creating a diffraction image of the waved surface structure in the secondary-light beam. The occurrence of two intensity maxima immediately indicates the presence of a periodic wave pattern, whose period is evaluated through inverse proportionality from the spacing of neighboring intensity maxima, while the depth of the wave troughs is determined from the intensity of neighboring intensity maxima and from the period. The intensity distribution in the diffraction image in the secondary-beam path is subjected to an autocorrelation, and both the period and the depth of the wave pattern can be calculated from the autocorrelation function.